## REMARKS

Claims 32-52 are all the claims pending in the application. Claims 6, 13 and 23 stand rejected upon informalities. Claims 2, 3, 6, 9, 10, 13, 22, 24 and 26-31 stand rejected on prior art grounds. Claims 1-31 are cancelled without prejudice or disclaimer. Claims 32-52 are added herein. Applicants respectfully traverse these rejections based on the following discussion.

### I. The 35 U.S.C. §112, First Paragraph, Rejection

Claims 6, 13, and 23 stand rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement. Applicants have cancelled claims 6, 13, and 23 and have added new claims 32-52, and in doing so have removed the offending language to overcome the enablement rejection under 35 U.S.C. §112, first paragraph. Specifically, language pertaining to "sufficient thickness" and "sufficient intermetallics" have been removed. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw these rejections.

### II. The Prior Art Rejections

Claims 6, 29 and 30 insofar as being in compliance with 35 U.S.C. 112, stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kumar et al. (U.S. Patent 5,290,732) hereinafter "Kumar" in view of Cohen (U.S. Patent 6,136,707) and admitted prior art. Claims 9, 13, 22, 23, 24, 26, 28 and 31 insofar as being in compliance with 35 U.S.C. 112, stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kumar in view of Cohen and admitted prior art and Zhao et al. (U.S. Patent 5,674,787) hereinafter "Zhao". Claim 2 insofar as being in compliance with 35 U.S.C. 112, stands rejected under 35 U.S.C. §103(a) as being unpatentable

over Kumar in view of Cohen and admitted prior art as applied to claim 6 above, and further in view of Zhao. Claim 3 insofar as being in compliance with 35 U.S.C. 112, stands rejected under 35 U.S.C. §103(a) as being unpatentable over Kumar in view of Cohen and admitted prior art as applied to claim 6 above, and further in view of Mori et al. (U.S. Patent 6,335,570) hereinafter "Mori". Claims 10 and 27 insofar as being in compliance with 35 U.S.C. 112, stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kumar in view of Cohen and admitted prior art and Zhao as applied to claims 13 and 23 respectively above, and further in view of Mori. Applicants respectfully traverse these rejections based on the following discussion.

Kumar teaches ionized metal cluster beam deposition of metal bumps on substrates such as multi-chip modules and integrated circuit chips. Kumar discloses wet etching techniques for removing unwanted metal deposited on the substrate around bumps, and multiple sources for depositing alloyed (tin-lead) bumps with constant composition.

Cohen teaches a method for making metallic interconnects including: (a) forming a patterned insulating layer on a substrate, the patterned insulating layer including at least one opening and a field surrounding the at least one opening; (b) depositing a barrier layer over the field and inside surfaces of the at least one opening; (c) depositing a first seed layer over the barrier layer using a first deposition technique; (d) depositing a second seed layer over the first seed layer using a second deposition technique, the first and second deposition techniques being different; and (e) electroplating a metallic layer over the second seed layer, the electroplated metallic layer including a material selected from a group consisting of Cu, Ag, or alloys including one or more of these metals.

Zhao teaches a method of utilizing electroless copper deposition to selectively form

encapsulated copper plugs to connect conductive regions on a semiconductor. A via opening in an inter-level dielectric (ILD) provides a path for connecting two conductive regions separated by the ILD. Once the underlying metal layer is exposed by the via opening, a SiN or SiON dielectric encapsulation layer is formed along the sidewalls of the via. Then, a contact displacement technique is used to form a thin activation layer of copper on a barrier metal, such as TiN, which is present as a covering layer on the underlying metal layer. After the contact displacement of copper on the barrier layer at the bottom of the via, an electroless copper deposition technique is then used to auto-catalytically deposit copper in the via. The electroless copper deposition continues until the via is almost filled, but leaving sufficient room at the top in order to form an upper encapsulation layer. The SiN or SiON sidewalls, the bottom barrier layer and the cap barrier layer function to fully encapsulate the copper plug in the via. The plug is then annealed.

Mori teaches a semiconductor device capable of preventing diffusion of a particle of copper or the like which forms a conductive layer is provided without any increase in the number of manufacturing the steps. Further, a semiconductor device preventing diffusion of a particle forming a conductive layer into an insulating layer even when a width of the conductive layer is increased is provided in Mori. The semiconductor device includes: an insulating layer; a barrier layer; a conductive layer; a barrier layer having an opening; an insulating layer having a through hole 8 exposing a surface of conductive layer and a part of a surface of barrier layer; a barrier layer formed on a surface of said through hole 8 and insulating layer which is in contact with an upper surface of barrier layer; and a conductive layer filling opening and through hole.

However, independent claims 32, 38, and 44 contain features, which are patentably distinguishable from the prior art references of record. Specifically, claim 32 recites, in part,

"...wherein said solder bump is in direct contact with said second metal plug, said first barrier layer, and said second barrier layer...." Likewise, claim 38 recites, in part, "wherein said connector is in direct contact with said second plug, said first barrier layer, and said second barrier layer...." Similarly, claim 44 recites, in part, "wherein said conductive structure is in direct contact with said third layer of copper, said first barrier layer, and said second barrier layer." These features are clearly provided in the application as originally filed, and in particular in Figure 3.

These features are simply not taught or suggested in the prior art references of record. Namely, Kumar fails to teach all of the aspects of the claimed invention, as admitted in the Office Action. Nonetheless, the Office Action concludes it would have been obvious to combine Cohen, Mori, and/or Zhao in various combinations with Kumar to try and teach, but failing nonetheless, the claimed invention. However, even if Cohen, Mori, and/or Zhao were legally combinable with Kumar, they would still fail to teach all of the elements of the claimed invention. Specifically, nowhere in either Kumar, Cohen, Mori, or Zhao is it taught, shown, suggested, or implied that the solder ball (connector, conductive structure) is in direct contact with each of the third copper layer (upper metal plug), the first barrier/liner layer, and the second barrier/liner layer. Thus, each of the prior art references taken either individually or collectively fails to teach an element of the claimed invention, thereby favoring patentability of the claimed invention.

It is apparent that the prior art references fail to teach this aspect (direct contact of the solder ball to each of the upper metal plug and the first and second barrier layers) of the claimed invention. First, to begin with Kumar fails to teach a multi-level structure at all. Second, even

the extremely restrictive teachings of Kumar teach away from the claimed invention. As provided in Figure 10 of Kumar, the metal bump 44 is only in contact with the metal plug 44b and does not contact the barrier layer 18b. Similarly Figures 13-20 of Kumar clearly show the metal bump 22c, 40d, and 58 failing to contact more than one underlying layer (i.e., only barrier layer 18d is in contact with the metal bump 22c, 40d, and 58). Thus, Kumar teaches away from the claimed invention. Therefore, even if Cohen, Mori, and Zhao were combined with Kumar, they would still fail to teach this aspect of the claimed invention as neither Cohen, Mori, or Zhao teach solder ball technology, and simply only teach multi-layered structures. Thus, combining the multi-layered structures of Cohen, Mori, or Zhao with Kumar still fails to teach the claimed invention.

This aspect of the claimed invention is a significant improvement over the prior art because by having the solder ball directly contacting each of the upper metal plug along with both the first and second barrier layers the claimed invention's performance improves because it provides three separate barriers of impurity diffusion from the solder bump into the underlying metal lines. Conversely, Kumar merely provides a single barrier between the metal bump and the underlying metal lines, thus resulting in greater impurity diffusion from the metal bump to the underlying metal lines, thereby resulting in inferior device performance compared to the claimed invention. Moreover, because there is no teaching either Cohen, Mori, or Zhao of how or where the multi-layered structure would combine with a solder bump, it is unknown, or at the very least, unobvious that the multi-layered structure would combine with a solder ball such that an upper metal plug together with two barrier layers would each directly contact the solder ball. Such a reading would be illegally liberal and unjustified given that neither Cohen, Mori, or Zhao discuss

implanting solder ball technology with the multi-layered structures described therein.

Moreover, incorporating such features in Kumar, Cohen, Mori, or Zhao, or in any combination thereof would be unobvious because the material 40 in Kumar is taught as being thin, in order to maximize deposition throughput. That is because the material 40, as illustrated in Fig. 7 of Kumar is deposited using a focused ionized metal cluster beam deposition. As discussed at col. 5, lines 45-52 of Kumar:

> "...However, the first metallic bumps 40 are deposited in a thin form in order to speed up the fabrication of bumps. That is, the first metallic bumps 40, for example only, may be 500 angstroms thick of gold which are formed as in Fig. 3 by depositing the bumps 40 by a focused cluster beam. Because of the thinness of the first metallic bumps 40, they can be quickly fabricated over all of the pads 14a."

Cluster beam tools typically have low throughput. The point of Kumar's teachings is to address this problem by using the tool to make a thin deposition. Applicants respectfully submit that such language would tend to teach away, rather than toward, the claimed invention. The emphasis of this prior art teaching is the deposition of a thin bump layer, and not on depositing a layer thick enough to prevent penetration of materials from the solder bump as in the claimed invention.

Moreover, Kumar is unconcerned with the issue of material penetrating from the solder for a simple reason: the combination of materials used in Kumar would not have this problem. As discussed by Applicants at pages 2-3 of their specification, tin diffusing from solder does not react significantly with aluminum; it does, however, with copper. In Kumar the pad 14 is made out of aluminum. Therefore, there is no need for the metal 40 to be designed so as to prevent tin penetration into aluminum 14 because aluminum is not nearly as reactive as copper. Moreover, even if a person of ordinary skill in the art were motivated to replace the aluminum pad 14 in

Kumar with copper, the thin material 40 would not be sufficient to prevent the formation of tin-copper intermetallics.

Typically barrier materials prevent penetration of materials into underlying layers. As pointed out in their specification, the present inventors have found that solder materials such as tin can penetrate through barrier layers. None of the prior art references of record teach the use of any additional material to prevent penetration of materials from the solder. Nor do the prior art references teach that the metal plug has a thickness sufficient to consume tin diffusing from the solder bump. Rather, all of the prior art references of record teach that a barrier layer is sufficient for the job; other layers are used for other purposes. In the claimed invention, in order to prevent penetration of materials that can penetrate through barrier layers, the inventors utilize a pad that is made out of the same material as the underlying materials (i.e., copper). Therefore, the pad forms the same type of intermetallics that would be formed in the underlying layers; as such, the pad prevents these intermetallics from forming in the underlying layers. None of the prior art references of record teach or suggest this.

Furthermore, Zhao also teaches away from the claimed invention. Zhao teaches the inclusion of a diffusion barrier above the second layer of copper. The teaching of the diffusion barrier is key to the overall teachings of Zhao; specifically, Zhao states, "[s]ince copper diffuse/drift (sic, diffuses/drifts) easily in inter-level-dielectric (ILD) materials, copper interconnect structures must be encapsulated by diffusion barrier layers... Typically, the use of diffusion barrier material to encapsulate copper is not limited to the copper-ILD interface, but also to interfaces with other metals as well. Thus, copper encapsulation techniques are also used to isolate copper interconnect structures...from overlying metal layers where these metal layers

are formed from other than copper..." (Col. 2, lines 8-29; see also Col. 8, lines 8-31), emphasis added. Therefore, a person of ordinary skill in the art, in making the proposed combination, would apply both the copper plug 23 and the barrier 24 of Zhao, rather than simply the plug 23 and the underlying barrier. To do so as the Examiner suggest would be to ignore the plain teaching of Zhao. As such, Applicants respectfully submit that Zhao teaches away from, rather than toward, the claimed invention (wherein, as shown in Fig. 2 of the application, the solder ball 25 is disposed directly on the copper layer 24; the point of the copper layer immediately below the solder ball is to consume impurities, not to be protected from them (c.f. page 10, lines 2-7 of Applicants' specification).

With regard to Mori, there is no suggestion in Mori that the diffusion prevention device described therein may be used in a device employing solder bump technology such as the claimed invention. In fact, Mori provides "a semiconductor device having a conductive layer capable of effectively preventing diffusion of particles of copper..." (see Col. 2, lines 40-46), whereas the claimed invention tin from diffusing into the underlying copper layers. Thus, Mori is contrary to the claimed invention. Therefore, even if Mori were combinable with Kumar, it would still fail to show the elements of the claimed invention.

Insofar as references may be combined to teach a particular invention, and the proposed combination of Kumar, Cohen, Mori, and Zhao in combination with one another, case law establishes that, before any prior-art references may be validly combined for use in a prior-art 35 U.S.C. § 103(a) rejection, the individual references themselves or corresponding prior art must suggest that they be combined.

For example, in In re Sernaker, 217 U.S.P.Q. 1, 6 (C.A.F.C. 1983), the court stated:

"[P]rior art references in combination do not make an invention obvious unless something in the prior art references would suggest the advantage to be derived from combining their teachings." Furthermore, the court in Uniroyal, Inc. v. Rudkin-Wiley Corp., 5 U.S.P.Q.2d 1434 (C.A.F.C. 1988), stated, "[w]here prior-art references require selective combination by the court to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself. . . . Something in the prior art must suggest the desirability and thus the obviousness of making the combination."

In the present application, the reason given to support the proposed combination is improper, and is not sufficient to selectively and gratuitously substitute parts of one reference for a part of another reference in order to try to meet, but failing nonetheless, the Applicants' novel claimed invention. Furthermore, the claimed invention, as amended, meets the above-cited tests for obviousness by including embodiments such as the solder bump being in direct contact with each of the second metal plug and the first and second barrier layers as generally recited in the claimed invention. As such, all of the claims of this application are, therefore, clearly in condition for allowance, and it is respectfully requested that the Examiner pass these claims to allowance and issue.

As declared by the Federal Circuit:

> In proceedings before the U.S. Patent and Trademark Office, the Examiner bears the burden of establishing a prima facie case of obviousness based upon the prior art. The Examiner can satisfy this burden only by showing some objective teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teachings of the references. In re Fritch, 23 U.S.P.Q.2d 1780, 1783 (Fed. Cir. 1992) citing In re Fine, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988).

Here, the Examiner has not met the burden of establishing a prima facie case of obviousness. It is clear that, not only does Kumar fail to disclose all of the elements of the claims of the present invention, particularly, the solder bump being in direct contact with each of the second metal plug and the first and second barrier layers as discussed above, but also, if combined with Cohen, Mori, and/or Zhao, fails to disclose this element as well. The unique elements of the claimed invention are clearly an advance over the prior art.

The Federal Circuit also went on to state:

> The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. . . . Here the Examiner relied upon hindsight to arrive at the determination of obviousness. It is impermissible to use the claimed invention as an instruction manual or "template" to piece together the teachings of the prior art so that the claimed invention is rendered obvious. This court has previously stated that one cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention. Fritch at 1784-85, citing In re Gordon, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984).

Here, there is no suggestion that Kumar, alone or in combination with Cohen, Mori, and Zhao teaches a device containing all of the limitations of the claimed invention. Consequently, there is absent the "suggestion" or "objective teaching" that would have to be made before there could be established the legally requisite "prima facie case of obviousness."

Furthermore, as previously mentioned even if Kumar were to be combined with Cohen, Mori, and Zhao, it would still fail to teach the novel aspects of the invention. The invention provides a much more streamlined approach and a simpler concept than the proposed combination of Kumar, Cohen, Mori, and Zhao. Therefore, the invention is different from either Kumar, Cohen, Mori, or Zhao, whether alone or in combination with one another, and moreover,

the invention is unobvious in light of the restrictive teachings of Kumar, Cohen, Mori, or Zhao. Moreover, the fact that the Office Action is combining parts of four separate and mutually exclusive prior art references to try and teach the claimed invention is evidence of unobiousness.

Therefore, Applicants respectfully submit that the cited prior art of record do not teach or suggest the features defined by newly added independent claims 32, 38, and 44 and as such, claims 32, 38, and 44 are patentable over Kumar alone or in combination with Cohen, Mori, and Zhao. Further, dependent claims 33-37, 39-43, and 45-52, are similarly patentable over Kumar alone or in combination with Cohen, Mori, and Zhao, not only by virtue of their dependency from patentable independent claims, respectively, but also by virtue of the additional features of the invention they define. Moreover, Applicants note that all claims are properly supported in the specification and accompanying drawings, and no new matter is being added. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw the rejections.

## III. Formal Matters and Conclusion

In view of the foregoing, Applicants submit that claims 32-52, all the claims presently pending in the application, are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary.

Please charge any deficiencies and credit any overpayments to Attorney's Deposit

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Respectfully submitted,

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